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CHEMICAL CORPS MEDICAL LABORATORIES

SPECIAL REPORT

MLSR No. 61

CABIN AIR CONTAMINATION IN RB-57A AIRCRAFT

by

Ted A. Loomis, Captain, MC
Stephen Krop, Ph. D.

February 1955

Not for Publication

ARMY CHEMICAL CENTER, MARYLAND

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INTRODUCTION

At the request of Aero Medical Laboratory, Wright-Patterson Air Force Base, a proposal was submitted by the authors of this report to study the effects of the cabin air in RB-57A aircraft on personnel. A copy of the proposed study appears as Appendix 1. The purpose of the study was to attempt to reproduce the illness, and to note the effects, if any, on certain performance tests by personnel exposed to such cabin air. The original proposal did not include an extensive chemical analytical study of the air, although during the course of the study, chemical analyses of the air for normal atmospheric gases as well as carbon monoxide were made. Also, some samples of the air were analyzed by infrared spectrography.

The study has now been completed, and this report constitutes the final complete report on the procedures used, the results obtained, and the recommendations which seem appropriate as a result of the study.

The study was made through the cooperation of the Glenn L. Martin Company, Middle River, Maryland; the Applied Physiology Branch, Physiology Division, and the Pathology Branch, Clinical Research Division, of Medical Laboratories, Army Chemical Center, Maryland*; pilots and observers of the 16th Tactical Reconnaissance Squadron, (USAF), at Shaw Air Force Base, South Carolina; and forty-two volunteer subjects who were members of the U.S. Air Force stationed at the Army Chemical Center, Maryland.

The study consisted of three phases. The first phase was that of exposing human subjects in a test chamber to the air from the J-65-W5 engine in the manner in which it normally supplies air to the cabin of the RB-57A aircraft. This phase of the study will be referred to hereafter as studies at the "engine test facility." Included in the first phase of the study were two additional experiments involving spraying of engine lubricant into the intake of the engine while subjects were being exposed to the cabin air. The second phase of the study was that of exposing human subjects in the cabin of the RB-57A aircraft to the cabin air from the engine while the aircraft remained on the ground. The third phase of the study involved exposing human subjects to the air in the cabin of the same aircraft in flight. Common elements of the three phases of the program were that the subjects always breathed the air from the air conditioning system of the aircraft; that the subjects were required to fill out periodically a check list regarding symptoms, odor, and signs

* The authors wish to acknowledge the excellent cooperation and assistance throughout this study of Pfc. Marvin Grosslein, Mr. Harry Frankel and Pfc. Bernard Swetts, of these Laboratories.

of irritation; that the air was analyzed for oxygen, carbon dioxide, and carbon monoxide content; and that air or water-trap samples of the air were obtained for infrared spectrographic analysis.

APPARATUS AND PROCEDURE

The engine test facility consisted of a J-65-W5 turbojet engine (see reports by Glenn L. Martin Company, reports No. 1, Ground Test, and No. 2 Flight Test, No. AF-33-038-22617) on a test stand with the air conditioning system intact in a mockup of the wing of the aircraft. A schematic diagram of this conditioning system is presented in Figure 1. The outlet from the conditioning system was piped to the human exposure chamber. This exposure chamber consisted of the enclosed cab of an armament truck. Figure 2 consists of a photograph of the truck and engine test facility in position at the test site. With this apparatus, five subjects could be exposed at one period to the air from the engine. The air flow to the chamber was recorded and five thermocouples recorded temperatures of the air at the air inlet and at various areas within the chamber (Table I, II and III). Air from the chamber was continuously sampled through a vacuum line delivering the air to the analytical apparatus located in the ambulance (Figure 3), which was located about fifteen feet from the chamber. The air in the chamber was thereby continuously analyzed for oxygen content by the use of a Beckman oxygen analyzer. The chamber air was also analyzed every five to ten minutes for carbon dioxide content by the use of a modified Scholander (1) technique adapted for macromethods, and for carbon monoxide content by the use of the Mine Safety Appliance Co. carbon monoxide tester. Air samples for infrared spectrograph analyses were obtained either directly in five gallon glass carboys or by bubbling the air through a 50 milliliter water trap.

Exposures of the subjects were made in the afternoon of each test day. A physical examination and recent medical history was obtained on each subject on the morning of the test day. A follow-up physical examination and questionnaire was obtained on each subject on the morning following the day of exposure. Each subject was exposed for a total of sixty to eighty minutes in two periods of thirty to forty minutes each (Table IV)*. Three to five volunteer subjects and one additional person to conduct the tests (and on a few occasions two additional persons) entered the chamber, and the doors to the chamber were closed. The ceiling vents to the chamber were then opened to prevent pressurization within the chamber. At this time, a preliminary period of controlled determinations was made for the psychological tests which were to be conducted during the period of exposure. The nature of the psychological tests will be described in the following paragraph. The subjects were also

* The time for each individual exposure was limited by the amount of available fuel supply. The fuel supply was adequate either for exposure of forty minutes duration at 90% engine power, or for exposure for fifteen minutes at 90% engine power plus an additional fifteen minutes at 100% engine power. After such runs, it was necessary to stop the engine, refuel, and then conduct a second exposure period.

instructed on how to fill out a check list at specified times during the exposure period. Following this instruction, the engine was started and rapidly brought to 90% of its power rating. The air conditioning system was then turned on. Since the chamber contained no sound insulation, each subject wore Mine Safety Appliance Co. rubber ear "defenders" (M.S.A. No. HA-17225) for partial protection against the engine noise in order to approximate more closely the noise level as it exists in the cabin of the aircraft. The instructor then indicated the time to the subjects by writing it on a blackboard which faced the subjects. This was their signal to start filling out the check list. This procedure was repeated periodically every seven to ten minutes throughout the exposure period, thereby obtaining data uniformly on each subject. The subjects used the periods between the check list procedure to complete the psychological test sheets supplied to them.

Figures 4A and 4B are examples of the blank check list supplied to each subject. Figure 5 is an example of the instruction sheet which was given to each subject for the "reading type" of psychological test. Figure 6 is an example of the instruction sheet which was given to each subject for the "arithmetic type" of psychological test. No additional information regarding the psychological type of test was given to the subjects so that uniformity between all subjects regarding their knowledge of the test would be obtained. Figures 7A, 7B, 7C and 7D are examples of the "reading tests" which were given to the subjects during the exposure period. Figures 8A, 8B, 8C and 8D are examples of the "arithmetic test" which were given to the subjects during the period of exposure. These particular physiological-psychological tests were selected for use in the present experiments, not only because of feasibility in the close quarters of the test chamber, but also because one of us has had considerable experience in the use of these tests for determining depression of physiological and psychological function resulting from certain depressant drugs. Therefore, the tests were well standardized in the hands of the present investigators.

The "ground-runs" in the aircraft consisted of exposing a single subject (because of space limitations) in the observer's seat in the cabin of the aircraft to the air from the engines with the cabin dump valve closed. The engines were started, brought to 90% power for thirty minutes, and then run at 100% rating for an additional ten minutes while the subject respired the air from the normal conditioning system of the aircraft. During the exposure, the subject was required to fill out a modified check list, an example of which is presented in Figure 9. Carbon monoxide was determined periodically during the exposure. Five minutes after the engines were brought to 100% power rating, the subject obtained a five gallon sample of cabin air, which was then sealed and brought to the laboratory for infrared analysis.

Following the "ground-run" each subject was given flight gear and instructed in the use of the ejection seat. The subject was then subjected to the "flight-test" portion of the program. The "flight-test" consisted of flying the aircraft while the pilot breathed 100% oxygen, and the subject breathed the cabin air with the dump-valve on. The plane was taken to approximately 10,000 feet altitude and cruised at approximately 90% of power for thirty minutes. Following this, the aircraft was brought to a 2,000 foot altitude, and, with the dive brakes open, the engines were set at approximately 96% of power. At this time, a five gallon cabin air sample was obtained by the subject and the container was sealed for later infrared analysis at the laboratory. (On one additional flight, a water trap sample was obtained by passing fifty-six liters of the cabin air through a fifty milliliter capacity water bubbler trap.) The pilot then took the aircraft to 10,000 feet altitude until approximately sixty minutes after the take-off had elapsed thereupon returning the aircraft to the landing field. Periodically during the flight, the subject filled out the check list, an example of which is presented in Figure 9.

In addition to the "flight-tests" described above, which were conducted at the Glenn L. Martin facility, one of the authors (T. A. L.) spent a week at the Shaw Air Force Base, South Carolina, for the purpose of obtaining additional "flight-tests" data. For this, navigator volunteers stationed at that base were used as subjects during their regular flights in RB-57A aircraft. With the cooperation of the personnel at Shaw Air Force Base, the pilots and navigators were briefed regarding the purpose of the study. The pilots were to fly the planes using 100% oxygen, but the navigators were to breathe cabin air from the air conditioning system with the dump-valve open and at approximately 10,000 feet altitude. During this time, the navigators were to fill out a check list (example of the check list is presented in Figure 9) and were also to obtain twenty milliliter samples of the cabin air in special apparatus devised for the purpose. The air samples were analyzed for oxygen, carbon dioxide, and occasionally carbon monoxide content.

RESULTS: ENGINE TEST FACILITY

A total of forty-one human volunteer subjects were exposed to the air from the engine while in the chamber at the engine test facility. There were seven groups of five subjects each, one group of four subjects, and one group of two subjects. Experiments were conducted on eight different days. In addition, one of the authors was exposed for eight of the nine experimental runs for a total of approximately eight hours. One of the authors' assistants was also exposed for four experimental runs or for a total of approximately five hours exposure. The number of subjects and duration of each test exposure is summarized in Table IV.

a. Summary of Odor Data.

During the first period of exposure, five subjects stated no odor was present throughout the test period. The remaining thirty-six subjects reported an odor when the air from the engine was first allowed to flow into the chamber. Of this group, fifteen stated that the odor disappeared after ten to fifteen minutes of exposure. The remaining twenty-one subjects stated that the odor was still present throughout the test period. Only one of these subjects described the odor as increasing in intensity from mild to medium as the test period progressed. The remaining subjects described the odor as being mild in intensity.

Thirty-one of the subjects were exposed in the chamber to a second period of breathing the air from the engine. Eighteen of these subjects stated that no odor was present throughout the test period. Thirteen subjects of the total group stated the odor was present. Eight of these thirteen subjects stated this odor disappeared after ten to fifteen minutes, and the remaining five subjects stated that the odor persisted throughout the test period. All of the subjects who detected an odor described it as being mild in intensity.

The nature of the odor was described by the various individuals in this study as follows: twelve subjects described the odor as being of the nature of burning rubber or rubberish, four subjects described the odor as being similar to that of burning or scorched cloth, three of the subjects described the odor as being similar to burning electrical insulation, and one subject described the odor as being similar to one or more of the following types of odors: burning kerosene, hot oil, diesel exhaust, tunnel fumes, hot metal, or hot paint. The remaining twenty-one subjects did not indicate that they could recognize the nature of the odor.

b. <u>Summary of Other Subjective Findings</u>.

In a total of forty-one subjects, smarting of the eyes was described as being present by only one of the subjects and this occurred only at the beginning of the test and disappeared after ten to fifteen minutes of exposure. Two subjects described no effect on the eyes at the beginning of exposure but after ten to fifteen minutes of exposure, these subjects described a slight smarting of the eyes. The thirty-eight remaining subjects indicated that there was no effect on the eyes.

With respect to effects on vision, hearing, and nausea, no subject described any deviation from normal.

With respect to fatigue as a subjective feeling, twenty-one of the subjects described no fatigue during the exposure. All of the remaining twenty subjects started the exposure with no tiredness, but after ten to fifteen minutes, fifteen of these subjects described mild tiredness, which progressed to moderate tiredness by the end of the second exposure. Of this latter group, one subject exhibited extreme sleepiness from which he rapidly recovered when the test was completed and he was allowed to go out into fresh air. (This subject had received a normal night's sleep prior to the test day.)

With respect to anxiety as a subjective feeling, thirty-seven of the subjects stated they had no anxiety throughout the tests. Four subjects started the tests with no anxiety and one of these developed moderate anxiety when the temperature was raised late in the exposure period.

All of the subjects indicated that they had a feeling of well-being and were not particularly concerned about any possible hazard as a result of being exposed to the air in the chamber.

Headache occurred in three of the subjects late in the course of the second exposure. Headache was not present prior to entrance into the chamber, and did not clear up until from one to three hours after the subjects left the chamber.

Only one subject developed additional symptoms of any consequence during the exposure to the air from the engine. This subject developed, after ten minutes of exposure to the air, a slight "light-headedness." This he described as being also accompanied with mild dizziness. These symptoms became more intense as the exposure period was continued. The symptoms tended to clear up during the re-fueling pause, i.e., while the subject was breathing atmospheric air. At the end of the re-fueling period, the subject was exposed for an additional thirty-two minutes, during which time the light-headedness and dizziness tended to improve rather than to get worse. None of the other subjects, out of the total of forty-one, developed any symptoms of light-headedness, nausea, dizziness or gastrointestinal upset.

It is of some importance to make a statement regarding the subjective findings as observed in himself by one of the authors who was present during all except one of the exposure periods, or for a total of approximately eight hours exposure. This investigator breathed the air in exactly the same manner as the subjects. There was no evidence of alteration in vision, no smarting of the eyes, no subjective change in hearing, no fatigue, no nausea or anxiety with respect to the breathing of the air during the exposure periods.

c. <u>Psychological Determinations</u>.

The data obtained from the psychological tests which were given to the subjects during their exposure were statistically analyzed. This analysis indicated that there was no decrease in efficiency with respect to the subjects' ability to carry out the simple arithmetic tests or to carry out the simple reading tests used in this series of experiments. In the authors' experience in the past with respect to the use of these tests for determining decrease in the physiological or psychological functions, which these performance tests may measure, the test results as obtained indicated that the ability of the subjects to perform the tests was not significantly altered from normal as a result of exposure to the chamber air.

The physical examinations given the subjects prior to their exposure to the air from the engine in all cases were within normal limits. Analyses of the blood for hemoglobin were normal. Red, white and differential white blood cell count were normal in all cases. This type of information indicated, as was suspected, that the subjects were in good physical condition at the time that they were exposed. Subjects were also given the Romberg test for vestibular function and all were found negative prior to the experimental period. The history of the subjects could not be contributory except that there were seven subjects who on the night previous to the experiment had taken from four to eight bottles of beer. There was no difference found in performance or symptoms in the subjects who had had alcohol on the night prior to the experiment as compared to the subjects who had abstained the night before.

A "follow-up" physical examination and a brief questionnaire regarding the previous night's subjective feelings were conducted on the morning following the exposure of each subject. This "follow-up" examination indicated that there was no alteration in any of the subjects with respect to physical findings. On the night following the test period, it was found that twelve of the subject reported moderate to extreme fatigue beginning shortly after they had had their evening meal. This fatigue was sufficiently great to impel all of these subjects to lie down and rest. After lying down, they promptly went to sleep, and slept for from three to five hours. Upon awakening, ten of these subjects decided that they should retire. They slept the remainder of the night, waking the next morning completely refreshed. This history is believed to be significant because each one of the subjects stated that this was not their normal activity following their evening meal. In fact, all of these subjects stated that they were not in the habit of sleeping after the evening meal but rather, they usually occupied themselves with some chore around their household. The experiment was therefore a fatiguing experience for the subjects. It is also of some significance that the observer who was exposed for seven of the eight days of testing also experienced, for the first three days of exposure, the extreme fatigue occurring following the evening meal, and just as the remainder of the subjects, decided to sleep at that time. After the first three days, the observer, who was exposed during the test periods, noticed that this fatigue no longer occurred.

d. <u>Chemical Results on Chamber Air</u>.

During the test periods, the oxygen tension was never below 154 millimeters of mercury, the carbon dioxide concentration was never above 0.5%. In all tests except one, carbon monoxide was not detectable. In the single test where carbon monoxide was picked up by the apparatus, the concentration at that time was 0.001%. The data are presented in Table IV.

e. <u>Effects of Exposure to the Engine Air While Lubricant was Sprayed into Engine Intake</u>.

Because of previous knowledge gained from animal experiments that thermal break-down products from the engine lubricant can lead to pathological changes in the lungs of animals, these experiments were approached with considerable caution. In the first experiment, oil was injected into the intake of the engine while the engine was at 90% power rating. The rate of injection of oil into the engine was varied from

1/2 gallon per hour to six gallons per hour. At this time, two subjects were in the chamber and were breathing the air delivered by the engine while the rate of oil injection was gradually increased. The first experiment gave the following information. At an oil injection rate of 1/2 to 1 gallon per hour, no difference in odor and no subjective signs or symptoms were observed by the subjects as a result of breathing this air for approximately five minutes. It was not until the rate of injection reached three gallons per hour that the subjects noted smoke in the chamber. Therefore, it took an injection rate of approximately three gallons per hour to produce visible smoke in the air conditioning system. No symptoms or signs of irritation were noticed by the subjects as a result of breathing this air for a period of about three minutes. At the end of this time, the rate of injection was increased to four gallons per hour, resulting in recognizable smoke in the chamber. The smoke was slightly irritant to the eyes, it had no definite odor different from that previously described. It had an irritating effect on the upper pharynx, and it produced a slight feeling of "tightness" in the chest, following one to two minutes of inhalation. The rate of injection was then increased to six gallons per hour and at this time a rather dense smoke resulted. After breathing this for approximately one minute, the two subjects in the chamber noted marked irritation of the eyes, a nasal discharge, irritation in the nose, and upper pharynx resulting in mild coughing, and a slight "tightness" in the chest. The experiment was then discontinued for that day, and the subjects left the chamber. At this time, or within five minutes after termination of exposure, both subjects noticed a slight nausea, and both subjects noticed a definite feeling of "tightness" in the chest. Neither subject noticed any light-headedness. All of the symptoms rapidly cleared up within the next thirty minutes except for "tightness" in the chest and a slight, rapidly disappearing upper pharyngeal irritation.

The following day the subjects appeared normal and had no complaints, and therefore the experiment was continued for a second exposure period. It was decided to expose the two subjects to the air in the chamber when the rate of injection of the fuel was one gallon per hour. This was done, and the following results were obtained. During the exposure no definite smoke was noticed in the chamber. The subjects were asymptomatic for the first twenty minutes.

At this time, the subjects each began to notice a slight irritation in the nose with some "running of the nose," a mild upper pharyngeal irritation, and a slight "tightness" in the chest. This did not seem to become more intense as the experiment progressed to thirty minute exposure time, when the exposure was terminated. At this time, or within approximately ten minutes, the subjects noticed a very slight nausea. No light-headedness occurred, and the Romberg test was negative. The pharyngeal irritation persisted, but the nasal irritation seemed to subside. One to two hours following the exposure period, both subjects noticed a marked decrease in all symptoms and within three to four hours following the exposure the subjects were asymptomatic. There were no sequelae.

RESULTS: EXPERIMENTS CONDUCTED IN THE CABIN OF THE B-57 AIRCRAFT ON THE GROUND

Four subjects were exposed to the cabin air of a B-57 aircraft, with engines running but while the aircraft remained on the ground, in a manner described in the introduction to this report. All of these subjects had previously been in the "engine test facility" chamber. The subjects uniformly reported an odor identical with the odor which they had noticed in the chamber at the engine test facility. During the test, the temperature was periodically raised and lowered to a level where it became uncomfortably hot or uncomfortably cool. It was the impression of the subjects that the intensity of the "rubber-like" odor was greater when the temperature was raised to uncomfortably hot levels than when the temperature was reasonably cool in the chamber. No irritation of the eyes, or pharyngeal or nasal irritation was noticed by any of the subjects in this test. No other symptoms appeared.

RESULTS: EXPERIMENTS CONDUCTED IN THE CABIN OF THE B-57 AIRCRAFT IN FLIGHT

Each of the four subjects who had been exposed to the engine air of the aircraft while on the ground was subsequently taken aloft in the same aircraft. The pilot was directed to breathe 100% oxygen, and the subject was directed to breathe the cabin air, unless he developed symptoms which indicated to him that he should no longer breathe the air. As a result of these flight tests, three of the four subjects developed no symptoms which they could attribute to the breathing of the air from the engines while the plane was in flight. One of the subjects developed a rather marked nausea approximately eighteen minutes after the take-off. The nausea persisted in spite of the fact that the subject then took 100% oxygen by oxygen mask and the subject gradually developed light-headedness. Approximately forty minutes after take-off the subject vomited. Following the flight the subject was taken to a shower room and questioned respecting the nature of the illness. In the hope of excluding motion sickness, the subject was sent aloft the following day breathing 100% oxygen. After about thirty to forty minutes of flight, he developed a moderate amount of nausea, and the flight was terminated. On questioning, the subject described his subjective feelings as being similar to those which occurred on the previous day, in spite of breathing 100% oxygen throughout the second test period. Those results indicate that the illness seems beyond question to have been motion sickness.

In the observations made on Shaw Air Force Base personnel on their routine flights, the following data were obtained. Twelve subjects on twelve different flights in four different aircraft completed the test consisting of breathing the cabin air for the first thirty minutes of flight. Eleven of these twelve subjects reported no symptoms as a result of breathing the air. After twenty minutes of flight, one subject reported a very slight headache which extended across his forehead. At this time, he started taking 100% oxygen through the oxygen mask and in approximately five to ten minutes the headache had disappeared. Chemical analyses of the air for carbon dioxide indicated that the carbon dioxide content was less than 0.5% during the test. Oxygen concentration was uniformly between 19.5 and 20% oxygen. In all experiments, no carbon monoxide was found in the cabin of the aircraft.

DISCUSSION

At the start of the present study, the authors requested statements by three pilots who had complained of illness while flying RB-57A aircraft sometime prior to our tests (Appendix 2). It should be noted that these illnesses occurred at a time when no liquid oxygen was available for use in the aircraft. The illnesses also occurred shortly after a fatal crash of an RB-57A aircraft at Shaw Air Force Base. The official USAF investigation of that fatal crash ascribed the crash to an explosion in the battery compartment of the plane, thereby resulting in electrical failure and loss of control of the aircraft. In spite of this interpretation of the cause of that crash, because of the time proximity of the crash to the first appearance of cabin-air illness and because of the fact that the crash occurred (at approximately noon) in full view of many observers, the possibility of apprehension and of an epidemic of doubt among flight personnel concerning the reliability of the aircraft should be considered. Furthermore, since these illnesses had occurred in the personnel while flying the aircraft, subsequent occurrence of illness which might possibly be due to the cabin air was not reported because the pilots and navigators were allowed to fly only while respiring 100% oxygen supplied by the face mask. This is now reported to be required not only of pilots in the USAF but also of pilots at the Glenn L. Martin Company. However, it has come to the attention of one of us that some service personnel who fly the RB-57A aircraft daily often do so while respiring cabin air. Three pilots admitting such exposure to cabin air on repeated occasions have failed to develop untoward physical symptoms.

Because of its pertinence to this study, appended to this report is an official copy of the statements made by those individuals in the USAF who previously reported illness from cabin air in the RB-57A aircraft (Appendix 2). These symptoms as reported can be summarized as follows: two pilots complained of dry mouth, one each of faintness, light-headedness, inability to coordinate eye movements, and nausea. The symptoms cleared when the pilots switched to "ram-air" in two of the cases, and when the clear vision window was opened in the third case. With these symptoms as a guide to the nature of the possible illness resulting from exposure to the cabin air of the aircraft, the present study was designed to ascertain whether or not such illness could be reproduced by the engine air under the experimental conditions.

The results of experiments conducted at the engine test facility demonstrated that no significant illness or impaired physiological or psychological function would result in the human subject from breathing the engine air. The fact that one subject did develop nausea and light-headedness is well within the possibility of accidental or coincidental occurrence of such illness in any group of this size. Headache also occurred in an insignificant number of subjects. Furthermore, repeated exposure of one of the authors for sixty to eighty minute periods for seven nearly consecutive exposures (four exposures daily for four days then two days with no exposure, then two days with exposure, then one day with no exposure, followed by a final exposure day) failed to produce any symptoms other than the fatigue which is described in the results.

The mechanical arrangement of the apparatus supplying engine air to the cabin presents the possibility of the air becoming contaminated with engine lubricant from the front main engine bearing. This is true only if the front main bearing seal was not adequate to prevent leakage of the lubricant. Furthermore, maintenance crews declared that various engines consume different quantities of the lubricant. It has therefore been considered possible that in some of the aircraft, engine air could be contaminated with more or less of the lubricant, or its breakdown products. The lubricant might be partially broken down in the process of compression and temperature rise (from atmospheric temperature and pressure to approximately 625°F. and to 125 pounds per square inch. Furthermore, data regarding the fact that the breakdown products of the engine lubricant can be toxic to animals is now available (2,3). That this can even lead to the appearance of a fog or smoke in the cabin of certain aircraft has been described (3,4). The latter report states that the breakdown products of the lubricant can lead to degenerative changes in the livers, kidneys, and brains of rats, rabbits and guinea pigs exposed experimentally within the cabin of the plane. The present studies involving exposure of humans to the cabin air at the engine test facility while the lubricant was sprayed into the intake of the engine demonstrated that illness can occur as a result of such exposure. The nature of the illness is predominantly the result of irritant agents in the air, and results chiefly in eye, nasal, and pharyngeal irritation. If exposure is continued pulmonary and gastric symptoms develop. Smoke or fog is not an adequate indication that excessive lubricant is being used by the engine as symptoms appeared before amounts of the lubricant great enough to produce smoke were present. It would be reasonable to expect <u>similar illness following prolonged exposure to even lower concentrations of the lubricant</u> (and/or its breakdown products) than were used in this study. Furthermore, it should be remembered that of the total amount of lubricant sprayed into the engine intake only a small fraction of the lubricant or its breakdown products would enter that portion of the air which ended as cabin air. This makes it entirely feasible to fail to find the contaminating agent or agents by chemical analyses of the air unless their identity is known and special techniques are used to determine quantitatively their presence.

There are indications that at least some of the breakdown products of the engine lubricant are saturated and unsaturated aldehydes (2). The literature (5) indicates that the lower aliphatic unsaturated and saturated aldehydes in low concentrations are predominantly irritants to the eyes, nasal mucosa and airway of animals. The unsaturated aldehydes (e.g., acrolein and croton aldehyde) are the most toxic of the group commonly known. It is estimated that 75 micrograms of acrolein per liter of air is the highest concentration that can be tolerated for a period of several hours without serious symptoms. The toxic action these agents possess resembles strongly that observed in the present experiments, and in its quantitative aspects is quite consistent with the chemical findings of all the workers in this laboratory who have studied the problem thus far in animals.

While the engines of the RB-57A aircraft are operating on the ground (and also at the engine test facility) the lubricant from the middle and aft main engine bearings which is dumped overboard as a smoke spray can under certain conditions re-enter the engine intake. As this spray is being discharged from the engine, it strikes the ground and usually part of it is drawn into the air in the area of the engine intake by virtue of air turbulence and wind conditions. In this manner, the lubricant can normally enter the engine when the plane is on the ground, but this would be an unlikely occurrence when the plane is in flight. Apparently, then, some lubricant contamination can normally occur when the plane is on the ground, but this contamination is not sufficient to produce symptoms in the forty minute exposure period conducted in this study in the cabin of the aircraft or in the exposures at the engine test facility with the forty-one subjects used in the present experiments.

The fact that a significant number of subjects described an odor (predominantly rubberish, or burnt rubber) present in the cabin air makes it possible for most cabin occupants to recognize that something is in the air. This, together with any possible pre-existing suspicion of hazard from breathing the air in this aircraft could readily promote development of a psychological state in flight personnel leading to organic physical symptoms. The present experiments obviously do not prove or disprove this possibility as a cause of illnesses reported outside of this study.

CONCLUSIONS

Under the several conditions of this study, the normal engine air of the RB-57A aircraft was found to be safe for human use. The air contains a definite odor but no visible smoke. Additional experiments indicated that if the engine air was contaminated with sufficient lubricant untoward symptoms appeared in subjects exposed to this air. The results of the study indicate the following. Special attention should be directed towards evaluating the oil consumption of each engine at reasonably frequent periods. Smoke does not appear in the cabin until amounts of the lubricant greater than that necessary to produce illness are present. The earliest signs of the presence of excessive lubricant or its breakdown products in the air are eye, nasal and pharyngeal irritations. Longer exposure results in nausea and "tightness" in the chest. The present experiments indicate that the maximal allowable consumption of engine lubricant is less than one gallon per hour but is greater than one pint per hour probably depending mainly on the exposure period. Further experiments would be required to determine more exactly the maximal allowable use of the lubricant by an engine before symptoms of irritation or other symptoms would appear in personnel in the cabin of the aircraft.

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TABLE I

B-57 E.T.S.
CABIN AIR ANALYSIS TESTS

σ can be neglected

Engine Speed	Temperatures °C							Pressures							
% R.P.M.	Left Front	Right Front	Center	Left Rear	Right Rear	Before Orifice	After Orifice	Engine Bleed Total Psi	Engine Bleed Static Psi	Before Orifice Static " H_2O	After Orifice Static " H_2O	ΔP Orifice " H_2O	WA LB/Min	Date	Time
90	31	31	31	32	32	28	31	58	52	12.7	1.0	11.7	13.7	8/24/54	1615
90	33	33	33	33	33	41	41	58	52	13.0	1.0	12.0	14.0	"	1625
90	32	33	33	32	34	42	41	58	52	13.0	1.0	12.0	14.0	"	1635
90	28	30	30	30	32	0	4	58	51	7.0	0.8	6.2	10.0	8/25/54	1412
90	25	27	30	27	29	3	5	58	50	6.9	0.8	6.1	9.9	"	1417
90	24	24	28	27	29	3	5	57	51	6.95	0.8	6.15	9.9	"	1422
90	25	24	30	24	28	3	5	58	52	7.0	0.81	6.19	10.0	"	1432
90	23	24	30	24	30	3	4	58	52	7.0	0.8	6.2	10.0	"	1442
90	30	29	33	29	32	3	5	54	51	6.8	0.8	6.0	9.85	"	1517
90	27	26	32	26	31	3	8	55	51	6.9	0.8	6.1	9.9	"	1527
90	27	26	29	26	30	2	3	56	52	7.2	0.8	6.4	10.1	8/26/54	1349
90	23	23	24	25	28	2	3	56	52	7.0	0.79	6.21	9.95	"	1359
90	23	23	24	25	27	2	3	56	52	7.0	0.8	6.2	9.95	"	1409
90	24	24	24	24	27	15	15	56	52	9.6	0.96	8.64	11.75	"	1419
90	27	28	28	28	29	13	14	56	52	9.4	1.1	8.3	11.50	"	1447
90	26	27	27	27	30	15	15	56	52	9.4	1.0	8.4	11.60	"	1457
90	27	27	27	27	28	15	15	56	52	9.3	1.1	8.2	11.40	"	1507
90	26	26	26	26	27	16	16	56	52	9.3	1.1	8.2	11.40	"	1517

TABLE II

B-57 E.T.S.
CABIN AIR ANALYSIS TESTS

cr can be neglected

Engine Speed	Temperatures							Pressures							
% R.P.M.	Left Front	Right Front	Center	Left Rear	Right Rear	Before Orifice	After Orifice	Engine Bleed Total Psi	Engine Bleed Static Psi	Before Orifice Static " H_2O	After Orifice Static " H_2O	Δ P Orifice " H_2O	WA LB/Min	Date	Time
90	27	28	28	28	28	60	56	56	50	5.9	0.9	5.0	8.9	8/31/54	1508
90	30	30	30	30	30	49	48	56	52	4.0	0.7	3.3	7.2	"	1518
90	31	31	31	31	31	50	48	56	52	4.0	0.8	3.2	7.1	"	1528
90	30	30	30	30	30	49	47	56	52	4.0	0.8	3.2	7.1	"	1538
100	34	35	35	35	35	33	4	75	70	5.0	0.3	4.7	8.6	9/1/54	1436
100	36	36	36	36	36	48	47	75	70	5.0	0.3	4.7	8.6	"	1446
90	35	35	35	35	35	42	42	58	52	3.0	0.4	2.6	6.4	"	1456
90	34	35	34	35	35	41	41	58	52	3.2	0.3	2.9	6.7	"	1506
100	35	36	36	33	35	0	0	74	72	2.8	0.4	2.4	6.1	"	1538
100	32	30	33	30	33	0	0	72	70	3.2	0.8	2.4	6.1	9/2/54	1420
90	28	34	31	31	32	13	14	58	52	2.0	0.4	1.6	4.95	"	1435
90	31	30	33	32	33	10	11	58	52	1.8	0.4	1.4	4.6	"	1445
100	32	33	33	32	33	0	0	74	70	3.0	0.4	2.6	6.4	"	1515
100	27	28	28	28	30	0	3	74	70	3.0	0.4	2.6	6.4	"	1525
90	27	28	27	28	28	4	4	60	54	1.6	0.3	1.3	4.45	"	1535

TABLE III

B-57 E.T.S.
CABIN AIR ANALYSIS TESTS

σ can be neglected

Engine Speed	Temperatures							Pressures							
% R.P.M.	Left Front	Right Front	Center	Left Rear	Right Rear	Before Orifice	After Orifice	Engine Bleed Total Psi	Engine Bleed Static Psi	Before Orifice Static " H_2O	After Orifice Static " H_2O	Δ P Orifice " H_2O	WA LB/Min	Date	Time
90	27	26	26	26	28	0	0	58	53	10.4	2.0	8.4	11.60	8/27/54	1358
90	27	27	28	27	27	31	31	58	53	16.0	2.6	13.4	14.75	"	1408
90	29	29	29	29	29	34	34	58	52	16.0	2.6	13.4	14.75	"	1418
90	29	30	30	30	30	34	34	58	52	16.0	2.6	13.4	14.75	"	1428
90	27	28	28	28	28	20	20	58	52	15.4	2.6	12.8	14.40	"	1459
90	34	35	35	34	34	53	53	58	52	9.4	3.0	6.4	10.2	"	1509
90	35	36	36	35	36	54	54	58	52	9.4	3.2	6.2	10.0	"	1519
90	26	26	29	28	28	0	0	58	52	3.0	0.6	2.4	6.1	8/30/54	1415
90	25	24	27	28	28	2	2	58	52	3.6	0.8	2.6	6.4	"	1425
90	24	25	27	27	28	0	2	58	52	5.0	0.6	4.4	8.4	"	1435
90	24	24	28	27	30	0	2	58	52	3.5	0.6	2.4	6.1	"	1445
90	30	31	31	31	33	15	16	56	52	3.9	0.8	3.1	7.0	"	1512
90	36	37	37	37	37	79	76	56	52	3.9	0.8	3.1	7.0	"	1522
90	33	35	35	35	35	59	57	56	50	6.5	1.0	5.5	9.3	"	1532
90	36	38	38	38	38	68	66	56	50	6.5	1.0	5.5	9.3	"	1542
90	25	26	27	27	26	5	7	56	52	2.6	0.6	2.0	5.5	8/31/54	1357
90	26	27	28	27	27	15	15	56	52	2.6	0.6	2.0	5.5	"	1407
90	25	25	25	27	27	15	15	56	52	2.6	0.6	2.0	5.5	"	1417
90	26	26	27	27	27	14	16	56	52	2.6	0.6	2.0	5.5	"	1427

TABLE IV

DATE (1954)	DURATION (a) Run #1 (minutes)	DURATION (b) Run #2 (minutes)	Number of Subjects	O_2 Conc. (mmHg)	CO_2 Conc.	CO Conc.
Aug 24	38		5	154.	<0.5%	0
Aug 24		30	5	154.	<0.5%	0
Aug 25	40		5	159.5	<0.5%	0
Aug 25		22	5	159.5	<0.5%	0
Aug 26	42		5	159.5	<0.5%	0
Aug 26		41	5	159.5	<0.5%	0
Aug 27	42		5	161.	<0.5%	0
Aug 27		32	5	161.	<0.5%	0
Aug 30	37		5	159.5	<0.5%	0.001%
Aug 30		35	5	159.5 to 158.5	<0.5%	0.001%
Aug 31	43		4	159. to 158.5	<0.5%	0
Aug 31		41	4	159.5 to 158.5	<0.5%	0
Sep 1	35		5	160.5	<0.5%	0
Sep 1		8	5	160.5	---	0 (Fuel leak in engine)
Sep 2	32		2	160.5	<0.5%	0
Sep 2		34	2	160.5	<0.5%	0
TOTALS:	309	243	41			
	(552 minutes = 9.2 hours)					

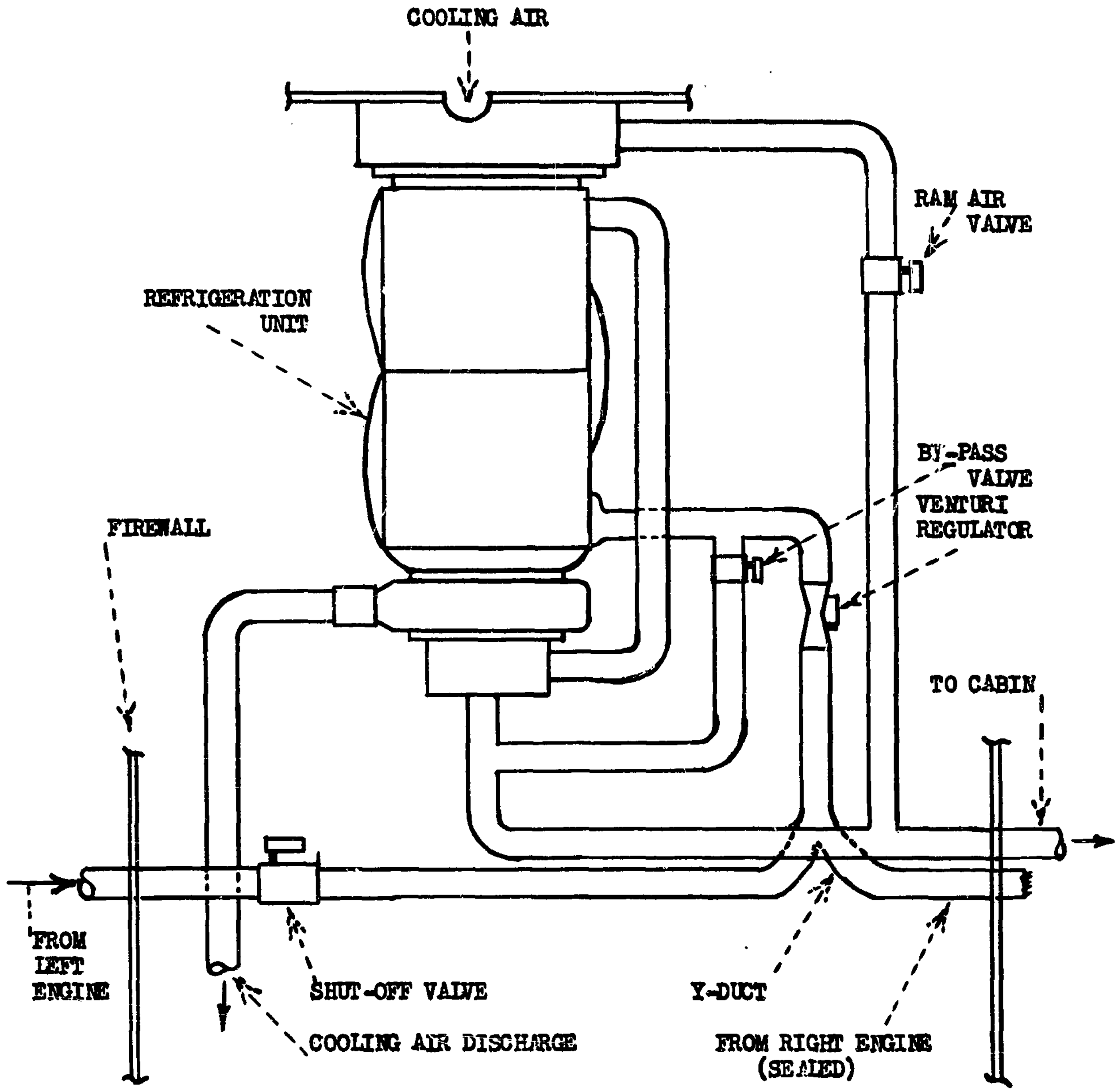

Fig. 1

SCHEMATIC OF COMPARTMENT CONDITIONING SYSTEM

Fig. 2

Truck and engine test facility in position at the test site; the enclosed cab of the truck was used as an exposure chamber.

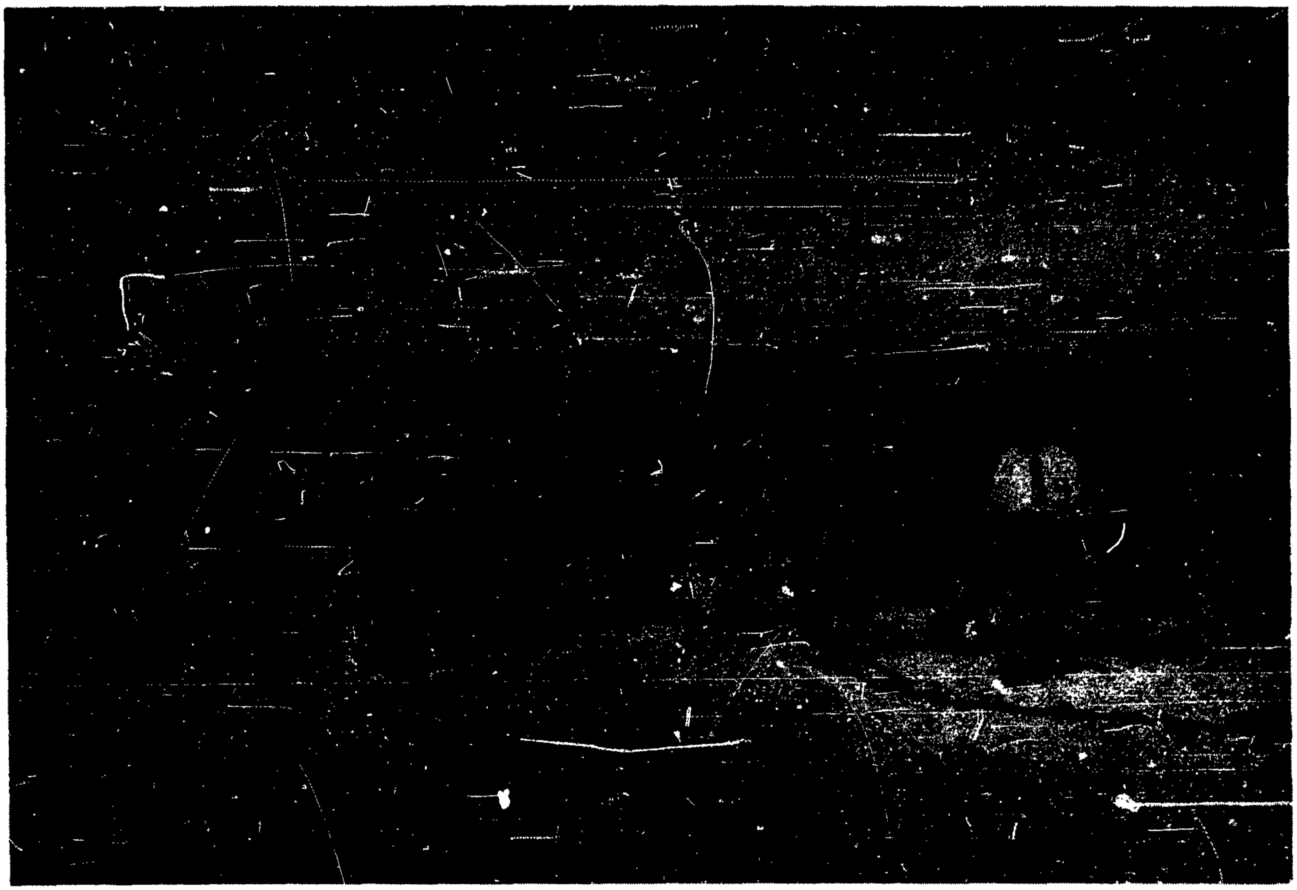

Fig. 3

Arrangement of equipment at engine test facility. Analytical apparatus for air sampling is located in Army ambulance at left of photograph.

NAME: ____________________

SUBJECTIVE FEELINGS

Time	Effects on Eyes				Hearing		Tiredness			Nausea		Anxiety				Feeling of Well Being		Other Remarks (Temp., Taste, Headache)
	Smarting		Vision															
	Yes	No	Normal	Not Normal	Normal	Not Normal	Mild	Med	Severe	Yes	No	No	Mild	Med	Severe	Yes	No	

010-36-54

Fig. 4A

NAME: ____________________

TIME	ODOR YES	NO	NATURE OF ODOR STRONG	MEDIUM	MILD	TO WHAT IS ODOR SIMILAR

Fig. 4B

Fig. 5

Read this page and do not turn to the next page until such time as you are told to do so. This page consists of the description of a reading type of test. Read this page, and if the nature of the test is not completely clear to you, ask the instructor any questions you may have regarding the test.

The following page consists of a typed paragraph which was obtained from published literature. The object of the test is for you to read the paragraph and each time that you see the letter "e" appear in a word in the paragraph, you are to place a circle with your pencil around that letter "e". Place the circle around the letter whether it is a capital "E", or a small "e". Proceed in this manner until you have made a circle around each letter "e" in the entire paragraph on the following. When you are reading the following page, do not hurry, but rather, proceed at a rate which is convenient for you. Do not go back to check your results. When you have finished the page, place your pencil in the clip at the top of your clip board and look at the instructor. This will be an indication to the instructor that you have finished the test. When all of the subjects have finished the test, the instructor will indicate for you to sign the page with your signature and pass it to him.

The following is a completed example:

Television is of recent origin and few of us have had much experience with it as an educational media. I have had none, first hand, but I have had some thirty years of experience with radio, and a good deal of experience in the production of educational motion pictures. These years of experience are warrant for my pessimism. The radio never has been effectively utilized as an educational medium.

Work the following example:

I am persuaded that we will never make effective use of radio and television until and unless we thoroughly and deeply analyze their communication assets and liabilities as educational tools.

Fig. 6

Read this page and do not turn to the next page until such time as you are told to do so. This page consists of a description of an arithmetic type of test. Read this page, and if the nature of the test is not completely clear to you, ask the instructor any questions you may have regarding the test.

The following test consists of a page of arithmetic problems. At the left margin of the page is a column of numbers selected at random. Each number at the left margin of the page is followed by a series of additional numbers. The object of the test is for you to mentally note the number at the left of the page, then start adding the numbers, going from left to right, until the sum equals the number which you have mentally noted. You are to make a vertical pencil line following the last number required to make the sum equal to the number at the left of the page.

Three completed examples appear below:

26   8 5 2 3 8 | 4 6 2 5 6 4 3

35   7 3 8 9 2 2 4 | 3 6 7 4 3

18   3 2 4 7 2 | 2 5 7 5 8 4 9

Work the following examples:

17   3 5 2 6 1 4 6 6 9 4 5 3

43   5 6 7 5 9 4 7 8 4 3 9 8

28   4 6 4 7 3 2 2 6 8 9 6 3

When you are told by the instructor to start the test, turn this page and start working the similar problems on the following page. Start at the top of the page and work each problem. Work the problems at a pace convenient for you. Do not hurry. Do not go back to check your results. Continue working all of the problems on the page without hesitation as you will be timed. Immediately upon completion of the last problem on the page, place your pencil in the clip at the top of your clip board, and look at the instructor. When all of the subjects have completed the test, the instructor will indicate for you to sign on the page with your signature, and pass it over to him.

Fig. 7A

It was not possible to determine the proportion of vitamin B_{12} present in whole blood prior to autolysis since alkaline treatment to destroy the vitamin invariably released greater amounts of vitamin B_{12} activity than was present in the original sample. The additional alkaline stable material is presumably due to liberation of desoxyribosides from the alkaline hydrolysis of nucleoproteins. The distribution of vitamin B_{12} between the plasma and the erythrocytes was calculated from the hematocrit and the data for whole blood and plasma vitamin B_{12}. For the mammals, the vitamin is almost equally distributed between the erythrocytes and plasma within the limits of experimental error. In contrast to the mammlian species, the vitamin B_{12} content of the blood from the chicken or alligator is largely present in the cellular fraction. This activity may be associated with the high nucleic acid content of the nucleated erythrocyte of these animals.

Fig. 7B

Successful and progressive growth of homografts of a transplantable tumor has been induced in normally resistant mice of an inbred strain by pretreating the hosts with killed homologous tumor tissue, normal serum or anti-serums to the tissues. The term homograft, as used here, denotes a graft between animals of the same species but of differing genetic backgrounds. The present investigation is one of a series directed toward elucidating the processes underlying the abrogation of resistance and deals with a study of the necessary time relationships between treatment of the otherwise resistant host and inoculation of the tumor homograft for successful survival of the graft. It was motivated by the observation that tumor homografts often exhibit marked growth before regression.

Fig. 7C

The increase in respiratory effort resulting from the administration of these drugs as recorded by pleural pressure changes as well as the simultaneous decrease in tidal volume are obvious. The subsequent influence of moderate doses of parasympatholytic agent in returning the pulmonary status to an approximately normal level are also demonstrated in the figure. A subsequent overwhelming dose resulted in only a slight transcient increase in respiratory effort and a terminal decrease in both the tidal volume and the respiratory effort. Venous pressure usually decreased immediately following the injection of the agent and then it rose above the control level. The rise in venous pressure was accompanied by a bradycardia. The resulting increase in venous pressure and the bradycardia were promptly reverted to normal by the administration of the parasympatholytic agent.

Fig. 7D

The fluorescent antibody technique was developed by Coons, and is a method in which antibody conjugated to fluorescein is employed as a specific histochemical stain for the localization of antigen in cells. The technique has been used to demonstrate antigens of rickettsiae and mumps virus, pneumococcus, friedlander bacillus, leptospira and homologous plasma proteins in tissues. The method was recently employed to show viral antigen in the inclusion bodies of canine distemper. Fluorescein isocymate was prepared and conjugated to protein of anti-canine distemper serum. Absorption of the conjugate on liver powder for preventing non-specific fluorescence in tissues was not found necessary in the smear preparations which were used. Smears were made on cover slips which were subsequently dried for 30 minutes before staining.

NAME:________________

27	4	7	4	5	2	5	3	7	9	8	8
14	2	6	6	2	3	4	8	2	8	6	4
36	4	2	6	4	8	4	8	6	2	4	1
41	3	9	5	6	8	2	3	5	1	6	4
42	2	4	6	8	3	3	8	7	1	2	8
32	8	2	4	9	9	2	6	3	7	1	5
33	7	2	3	4	9	3	2	3	3	7	6
39	4	3	6	3	8	4	3	5	2	1	4
24	1	5	8	3	3	4	8	6	1	2	2
15	6	7	2	8	7	6	5	2	9	7	1
31	2	3	7	4	1	3	2	9	1	1	2
46	1	7	3	8	3	1	2	4	8	6	3
37	9	2	1	3	8	3	7	3	1	9	6
22	3	4	2	8	5	2	3	8	7	9	3
25	6	2	8	3	6	2	8	6	4	9	7
12	1	6	4	1	2	3	6	8	2	4	4
13	3	6	2	2	1	4	3	9	2	2	9
40	2	8	3	6	4	9	2	6	8	2	3
28	6	3	8	6	3	2	4	7	2	9	6
18	7	6	2	1	2	2	4	3	9	2	1
16	2	5	2	3	4	2	6	8	3	9	5
34	8	6	4	8	5	3	2	6	3	7	2
35	8	3	7	7	3	6	1	3	6	4	7
47	5	8	6	3	7	8	3	5	2	3	4

Fig. 8A

NAME:________________________

36	8	7	3	9	2	4	3	5	8	9	2
32	3	6	5	9	2	1	3	3	7	2	9
24	5	1	6	8	2	2	7	6	4	2	2
46	3	9	6	4	8	5	7	4	6	3	7
25	2	5	8	3	7	7	2	6	3	1	2
40	5	8	3	6	5	2	8	3	7	3	9
16	4	9	3	7	2	1	7	6	5	4	3
47	9	3	1	6	7	5	2	4	8	2	7
14	2	8	4	4	7	3	8	1	2	8	9
42	6	9	3	7	2	5	1	8	1	2	2
39	8	5	3	7	2	4	1	9	2	8	6
31	4	6	3	1	7	2	8	8	5	2	2
22	1	3	4	8	1	5	2	6	3	1	4
13	5	8	3	7	2	9	6	2	8	2	4
18	5	7	3	3	2	8	3	7	1	5	1
35	8	1	7	6	5	3	5	2	9	7	2
27	8	3	5	4	3	4	2	7	6	8	1
41	2	9	3	6	8	5	2	4	2	9	9
33	3	8	4	7	2	8	1	5	4	3	1
15	6	5	4	2	8	7	2	7	8	5	3
37	7	9	3	6	1	9	2	3	4	3	4
12	5	3	4	7	2	9	1	6	7	2	7
28	3	6	8	4	2	5	4	3	9	2	5
34	4	7	3	8	2	6	4	6	2	4	8

Fig. 8B

NAME: ____________________

35	3	2	1	6	4	7	6	6	7	4	5
47	9	7	4	9	7	4	3	2	2	1	3
32	7	5	3	8	6	1	2	9	8	1	7
16	7	1	2	2	1	3	1	4	6	5	3
22	6	4	2	4	6	3	6	2	4	6	1
36	5	7	8	4	3	1	8	1	7	5	2
42	4	2	9	8	7	6	2	3	1	2	6
33	3	8	6	5	7	4	3	6	2	8	3
12	2	4	6	8	1	9	7	6	5	3	2
27	1	6	5	4	5	2	4	2	1	6	4
14	4	3	2	2	3	5	3	2	7	2	7
39	2	6	7	8	9	4	3	6	3	5	2
24	5	5	4	2	3	4	1	2	8	6	9
15	7	8	1	3	4	3	2	4	5	3	1
28	7	3	8	5	5	1	3	2	6	9	1
18	6	2	1	2	3	4	5	4	3	2	1
31	8	3	2	2	3	5	2	2	2	2	1
46	3	4	9	9	9	8	3	1	4	5	6
37	2	5	6	2	3	5	4	4	3	2	1
25	9	6	3	3	3	1	3	2	1	5	6
13	7	1	5	4	2	3	6	5	8	4	9
40	5	2	7	6	7	6	5	1	1	2	6
34	3	4	2	1	2	1	2	6	7	6	2
41	4	2	7	3	9	8	8	7	8	2	1

Fig. 8C

NAME:______________________

47	2	5	6	7	8	9	2	3	1	2	2
35	1	6	9	2	1	4	6	6	4	2	6
16	3	1	3	4	2	1	2	1	3	2	3
18	2	8	6	2	1	4	7	6	8	1	2
40	4	8	4	4	4	5	3	2	3	1	2
12	5	1	2	3	1	1	2	4	3	5	7
22	6	7	9	2	1	3	4	7	8	9	1
46	7	8	9	7	2	4	2	4	1	2	2
15	2	3	1	2	7	2	1	9	6	5	4
39	3	8	9	7	8	3	1	2	1	9	6
32	4	7	8	3	6	2	1	1	2	9	1
41	8	4	3	7	6	6	5	2	3	1	6
14	7	2	3	2	2	1	3	6	3	2	1
34	9	9	2	1	3	1	2	7	2	3	1
28	3	2	2	2	4	8	6	1	4	7	3
13	4	1	3	3	2	6	2	8	7	9	6
25	5	2	8	3	4	3	2	1	6	4	3
37	6	1	8	7	5	3	4	3	3	1	4
31	9	1	7	6	3	2	3	4	2	1	6
24	2	4	5	3	2	7	1	3	2	5	4
33	1	7	8	8	9	2	1	6	5	7	8
42	3	8	5	6	4	2	3	8	3	1	2
36	6	5	3	7	6	5	3	1	2	4	3
27	7	6	2	3	6	1	2	3	4	1	2

Fig. 8D

Name ______________________ Date ______________________

TIME	ODOR		EFFECTS ON EYES		TIREDNESS
			SMARTING	VISION	
	Yes or No	Nature of Odor	Yes or No	Yes or No	None, Slight, etc.

TIME	FEELING WELL	REMARKS
	Yes or No	Headache, nausea, temperature, taste, etc.

010-42-54

Fig. 9

APPENDIX I

TENTATIVE PLAN PROPOSED FOR STUDYING SUSPECTED TOXIC ORIGIN OF AIR CREW ILLNESSES IN B-57

(Unofficial)

Ted A. Loomis, Captain, MC
Physiology Division
Chemical Corps Medical Laboratories
Army Chemical Center, Maryland

The following is a proposed program for the experimental investigation of suspected toxic conditions resulting from personnel exposure to cabin air in B-57 aircraft. The problem has arisen as a result of reports of pilot illness (principally nausea) occurring during flight, and as a result of two plane and personnel casualties.

The official reports of the extent and nature of the illness and sequence of events leading to illness were not available at writing of this proposal; therefore, the present proposal is subject to alteration as may be indicated when these reports become available. The proposal is being made to obtain data pertinent to certain possible causes of the reported illnesses. These may be classed roughly as follows:

1. Toxic agents in the air supplied to the cabin
2. Psychogenic contributing factors
3. Previously existing medical and/or physical contributing factors

The following facilities for the study are to be made available by the Martin Aircraft Company at their plant in Middle River, Maryland.

1. A B-57 jet engine on a test block with facilities for simulating the situation existing in the B-57 plane. This consists of transferring air from the engine to a test room in the manner conventionally utilized in the plane for obtaining cabin air.

2. A B-57 plane arranged for use on the ground and in test flights as well as the personnel to operate the airplane and the engine.

3. Every effort will be made to have available those pilots and others who previously have reported illness in suspected aircraft.

The study is to be conducted under the direction of the author of this proposal on human subjects (and on some dogs as may be indicated), and is to consist of the following three major types of experiments:

1. Exposure for proper periods to the test room with the jet engine in operation.

2. Exposure for proper periods in the cabin of the plane on the ground with the engines in operation.

3. Exposure for proper periods in the cabin of the plane during flight.

Data will be obtained on each subject with respect to the following:

1. Data to be obtained a few days prior to experimental exposure:

   a. Initial thorough medical history
   b. Initial thorough medical examination
   c. Hemotology with C.B.C.
   d. Blood chemistry (CO_2 or Na or Methemoglobin)

2. Data to be obtained immediately prior to exposure:

   a. Physiological and psychological determinations

      (1) Reaction time
      (2) Alertness test

         (a) Arithmetic type
         (b) Reading type

      (3) Cycle test response to stress

         (a) Respiratory rate
         (b) Cardiac rate
         (c) Time for return to normal

      (4) Physical Examination

         (a) Peripheral and ocular reflexes
         (b) Romberg
         (c) Subjective symptoms

      (5) Immediate prior history

   b. Blood chemistry (CO_2 or Na or Methemoglobin)

3. Data to be obtained during exposure:

   a. Each subject is to be given a clip-board containing his instructions. At definite time intervals, he is to record in his own handwriting, on form supplied, any subjective symptoms he experiences. He will also be the subject of the tests for which the above listed control determinations were obtained.

   b. Samples of the atmosphere in the room as well as from the cabin of the plane will be periodically obtained. The source of air (ram air, engine air, oxygen mask) will be shifted at definite periods during the exposure period. The atmosphere samples will be analyzed for O_2, CO_2, and CO and whatever other agents indicated as a result of infrared and (if feasible) mass spectrometric analysis.

4. Follow-up studies on the subjects will be conducted on the day following exposure. Most of the subjects will be exposed on only one occasion but a few subjects will be exposed on as many occasions as indicated.

5. Dogs will be exposed at appropriate periods for special observations in the static test unit, and, if feasible, in the plane on ground level tests.

APPENDIX 2

Statements of Pilots Concerning Illness in RB-57A Aircraft

This report includes the histories on three pilots who complained of symptoms while flying the RB-57A. All of the pilots had their symptoms following the first crash of an RB-57A on this base and all of the pilots were flying at the time when no liquid oxygen was available for use in the aircraft.

1. The first case is that of a Senior Pilot who was flying on the 15th of May at 7,000 feet with the cabin pressurized and developed symptoms of dry mouth, a feeling of faintness, a subjective feeling of inability to coordinate eye movements, and nausea. In retrospect, the pilot feels that his breathing rate was increased. The symptoms came on gradually and when the pilot noted them, he opened his clear vision window in the canopy and his symptoms rapidly disappeared.

During the preceding 24 hours, the patient had had ample sleep, had eaten regularly and well, had not been drinking excessively and was taking no medications. At the time of this incident, the patient's health in the prior 24 hours was good, and he had no indication of respiratory infection, sinusitis, headaches, ulcers, ear trouble, hay fever, asthma, or eye strain. As with most of the pilots at the time of this incident, there was a considerable degree of apprehension involved in their attitude toward the aircraft they were flying due to the unexplained nature of the recent crash.

During the day in question, the weather was fair with scattered clouds. There was a moderate amount of turbulence and the temperature was 94°. There was a considerable amount of sunglare. Until the time this particular pilot opened his clear vision vent, the only ventilation he had in the cockpit was that afforded him by the pressurization of the cockpit.

2. The second case is that of a Senior Pilot who had been flying for 40 minutes at 7,000 feet and had descended to an altitude of 3,000 feet--who described a vague feeling of light-headedness and a "cool smell" which he feels he noticed in the cockpit. The smell and his symptoms promptly disappeared when he changed his ventilation switch to the "RAM" position. He had no other symptoms, and his symptoms were not present after landing the aircraft.

For the period of 24 hours prior to the flight, the pilot had had adequate sleep, had had regular well balanced meals, without excessive alcoholic intake, and was taking no medicines. His health is described as being excellent and he was not suffering from respiratory infections, sinusitis, headaches, ulcers, ear trouble, hay fever, asthma, or eye strain. As with most of the pilots in the squadron, there was a considerable degree of apprehension associated with flying the aircraft at that time due to the nature of the recent crash of an RB-57A.

The day of the flight, the weather was fair with scattered clouds with a moderate amount of turbulence. The temperature was 94°. There was a considerable amount of sunglare and the cabin was ventilated with the pressurization system.

3. The third case is that of a Senior Pilot who had been flying at 13,000 feet for a period of 45 minutes with the cabin pressurized and the dump valves opened. His symptoms were those of a dry mouth and a "tinny taste." The symptoms cleared when he changed his selector switch to the "RAM" position, affording circulation of the cockpit air. He had no symptoms after his landing the aircraft.

During the period of 24 hours prior to the flight, the patient had lived a moderate life with adequate sleep, normal well-balanced meals, and with no alcoholic intake. He was taking no medications. His health was excellent and he was not suffering from respiratory infections, sinusitis, headaches, ulcers, ear trouble, hay fever, asthma or eye strain. This particular pilot was under a moderate amount of emotional stress in his work and as in the case of the other pilots in the squadron, he was worried and under a considerable amount of stress because of the unexplained nature of the crash of an RB-57A just a few weeks prior to the time of this flight.

On the day of this particular flight, the weather was fair, there were scattered clouds. The temperature was 94°--there was a moderate amount of turbulance (sic) and a considerable degree of sunglare.

/s/M. C. CONNETT
1st LT, USAF (MC)

S T A T E M E N T

2 July 1954

At approximately 1530 hours on 15 May 1954, I was flying aircraft number 52-1436, an RB-57A, in a three (3) plane formation from Shaw Air Force Base, South Carolina. Approximately 40 minutes after take-off while flying over an overcast at 7000 feet, I experienced blurred vision, became nauseated and experienced considerable dizziness. I recall no strange or unpleasant odors, nor did I taste anything out of the ordinary. I did feel a definite dryness of mouth and throat.

This condition lasted possibly a minute or two. As I became more aware of the situation or nearly to the passing out point I recall dropping back from the formation and opening the clear vision window and unhooking the oxygen mask. Fresh air from this open window seemed to relieve the unpleasant conditions I felt.

At the time this condition occurred the aircraft pressurization was on for cooling purposes. The dump valve was open. The oxygen mask was secured to the helmet for ease of radio transmission. The oxygen mask hose was connected to the oxygen system in order that I might have the hose clamped to stop any swinging of this hose. The aircraft had not been serviced with oxygen. The cooling ports at both right rear and left rear position of pilots head were partially closed to stop large particles of ice from being tossed about the canopy.

I suffered no other ill effects for the remainder of the flight. Immediately upon landing I reported to the flight surgeon for any possible tests he might have felt needed.

During a period 24 hours prior to this flight I had:

I. a. Approximately 8 hours sleep.

b. Normal meals except meal prior to take-off was a sandwich and glass of milk eaten hurriedly. No alcoholic beverages, possibly 2 or 3 coca colas the morning of the flight.

c. No medications.

II. a. I have suffered acute sinusitis and plugging of left ear on occasion. I do not believe this condition existed at time of flight.

b. No headache 24 hours prior to flight.

c. No ulcers.

d. No hay fever.

e. No asthma.

f. No eye strain.

g. No emotional disturbances.

h. No unusual stresses in flight.

III. a. Weather broken at 6000-7000'.

b. Temperature at flight altitude, unknown; ground temperature, 65°-75°F.

c. 7000'

IV. a. Minor sun glare.

b. No unusual odors.

c. Blurred Vision.

d. Very nauseated.

f. Considerable dizziness.

g. Breathing rate unknown (presumed to be normal.)

h. Minor headache.

i. Mentally confused during sickness.

V. Minor headache following flight lasted approximately 5 hours.

/s/William J. Van Every
WILLIAM J. VAN EVERY
1st Lt, USAF

S T A T E M E N T

2 July 1954

At approximately 1530 hours on the 15 May 1954 I, Capt Joseph W. Comeaux, was flying aircraft number 52-1434, an RB-57A, in a three (3) plane formation from Shaw Air Force Base, S.C. Approximately 45 minutes after take-off, while descending from 7000 to 3000 feet I became slightly nauseated with a slightly dry, tin taste in my mouth. Not feeling comfortable I immediately changed my pressurization selector from PRESS to RAM position and closed dump valve. The feeling of nausea left me soon after changing to RAM position. At the time I was flying with oxygen mask hooked only on one side, hose not connected to the system. The formation flight lasted one hour and 45 minutes.

The following additional information in regards to the 24 hour period prior to this flight is submitted:

GENERAL:

a. Sleep - 8 hours.

b. Meals and drink - Normal. No alcoholic beverages.

c. Medication - None

HEALTH:

a. Respiratory infections - None

b. Sinusitis - None

c. Headaches - None

d. Ulcers - None

e. Ear trouble - None

f. Hay fever - None

g. Asthma - None

h. Eye strain - None

i. Emotional disturbances - None

j. Worries and unusual stresses - None

IN FLIGHT:

a. Weather - Fair, broken clouds at 6000 feet.

b. Temperature - 50°-60°F. at ground level, in-flight unknown.

c. Altitude (Max) - 7000 feet.

d. Ventilation - Pressurized, dump valve open then RAM-dump valve closed.

e. Sun glare - Very little from top of cloud deck.

f. Oxygen - None. Mask not hooked on helmet.

SYMPTOMS:

a. Odor - No unusual odors.

b. Eye effects - Not noticeable.

c. Nausea - Slightly apprehensive and fatigued. Changed from pressurization to RAM position and forgot about it. Fatigue due to trying to maintain formation.

d. Dizziness - None

e. Breathing rate - No change. Normal.

f. Vision difficulties - None.

g. Headaches - None

h. Mental confusion - None

i. Lethargy - None

AFTER EFFECTS: I experienced no after effects whatsoever.

/s/ Joseph W. Comeaux
JOSEPH W. COMEAUX
Captain, USAF

S T A T E M E N T

2 July 1954

At approximately 1015 hours on 16 May 1954 I became sick while flying RB-57A aircraft #52-1444. I was flying at 10,000 feet occasionally climbing over clouds up to 12,000 feet, aircraft had no oxygen aboard. I was flying with pressurization on, dump valve closed and full cold position due to heat. After being airborne approximately 45 minutes I became sick (metallic taste) to stomach with dryness of mouth, throat and stomach. Pressurization was turned off and clear vision panel opened and I immediately began feeling better. Flight was continued for about 1 hour and 15 minutes with no further effects during flight or after flight. I was breathing thru an oxygen mask with oxygen hose disconnected. After becoming sick I removed oxygen mask using thereafter to make radio calls.

PREVIOUS TO FLIGHT:

a. Sleep - 8 hours.

b. Food - Normal - No alcoholic drinks.

c. Medications - None

HEALTH:

a. Respiratory infections - None

b. Sinusitis - None

c. Hay fever - None

d. Asthma - None

e. Headache - None

f. Ear trouble - None

g. Ulcers - None

h. Eye strain - None

i. Emotional disturbances - None

j. Worries unusual - None

FLIGHT:

a. Weather - Clear - Occasional scattered clouds, visiblity excellent.

b. Temperature - 90° ground.

c. Altitude - 12,000 feet

d. Ventilation - Pressurization on, dump valve closed, cooling full on.

e. Sun glare - Very bright.

OXYGEN SYMPTOMS:

a. Eye effect - None

b. Nausea - Slight until clear vision panel was opened.

d. Dizziness - Slight until clear vision panel was opened.

e. Vision - Normal

f. Headaches - No

i. Mental confusion - No

h. Lethargy - No

When I started feeling sick I immediately made changes on pressurization system. Remainder of flight was normal. I did not check in with flight surgeon after flight.

/s/William Hardin
WILLIAM HARDIN
Captain, USAF

Medical Laboratories Special Report No. 61
Cabin Air Contamination in RB-57A Aircraft

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1. Cabin air, contamination, by engine oil breakdown.
2. Cabin air, odor.
3. Cabin air, physiol. effects.
4. Cabin air, psychological effects.